Univ. of Rochester

Interim Progress Report

Contract NASr-14

March 1, 1965 to May 31, 1965

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1) During this period work has continued on the rocket spectrograph. The optical system has been frozen and the grating ordered. Most of the mechanical decisions have been made and major castings have been ordered.

Throughout this period we have been making exposures on a special laboratory model of the spectrograph. We have been using SWR film, and SC5 in strips 18 cms by 35 mm. These tests show that the SC5 film is much faster than the SWR film and being in strip form it is easier to handle. The films we have obtained show a clear background and grain size well below a size which would cause loss of resolution.

2) Mr. Roy Frieden has carried out the following analytical work.

Analytical work

I. Expressions were found for the asymptotic dependence of the location and magnitude of the irradiance maximum upon third order spherical aberration, as the latter becomes large in magnitude. As usual, a Gaussian pupil function is assumed.

II. In my study of the imaging properties of laser radiation, many expressions have been derived linking parameters of the image

space - e.g., depth of focus, maximum Strehl, location of maximum Strehl - to the third-order wave aberration. It was accordingly thought important to be able to compute the third-order wave aberration for an optical system which is presently being used to focus a laser beam at the Institute. A spherical mirror is one example. A formula has thereby been found which predicts the (purely) third-order marginal wave aberration in terms of geometrical parameters of the mirror and the wavelength of light. The formula is very simple, and avoids the need for physically finding the marginal wave aberration, e.g. by use of a Twyman-Green interferometer. A serious disadvantage of a physical determination is that it is difficult to separate out the third-order aberration from fifth and higher orders.

Numerical work

I. Programming

The following programs have been written and case-tested, for study into my thesis topic. They also will be of value to experimentors with lasers, and those who intend to design lens systems for use in laser light.

(1) Numerical calculation of the point spread function formed by an optical system passing a laser beam and suffering from arbitrary amounts of third, fifth and seventh order spherical aberration. A uniform pupil irradiation may alternately be invoked. This program is used repeatedly by programs (2) - (4) below.

(2) Calculation of locus of points of equal irradiance (so-called "isophote curves"). A family of these curves was generated for

an optical system suffering one wave of third-order spherical aberration at the margin: the irradiance values were fractions 0.5, 0.6, 0.7, 0.8, 0.9, 1.0 of the irradiance maximum.

(3) Calculation of the two points where a given isophote curve crosses the optical axis. This is used in conjunction with (2), and also to compute the depth of focus when Strehl definition = 0.8 is taken.

(4) Calculation of the location and value of the maximum value of irradiance along the optical axis. The calculational uncertainty in location is also outputted. The irradiance maximum is required as an input number by program (2) above.

II. Non-Program Work

An expression was found for the maximum value S of Strehl definition in terms of an expansion to sixth power of the marginal third order wave aberration, θ. Program (4) above was used to generate an exact curve of S vs. θ, and the polynomial of degree six in θ was made to approximate the exact curve through proper choice of coefficients.

3) We have put together the components for a scanning knife edge test. This equipment will provide us with a nearly automatic lens test facility. The facility consists of the following items.

1) A scanning knife edge
2) A photomultiplier detector
3) A digital voltmeter
4) A magnetic tape unit
5) A FORTRAN program to convert from knife edge response to frequency response.

At present we are using an older version of the scanning knife edge. A new version is now being designed.

4) The Fortran version of Ordeals and Spryte is now nearly complete. This program has been segmented to enable it to fit on the IBM 7040, 7044 and 7092 type machines.